DOCUMENT RESUME

ED 293 715 SE 049 090

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TITLE Logical and Critical Thinking Abilities of Sixth through Twelfth Grade Students and Formal Reasoning Modes as Predictors of Critical Thinking Abilities and Academic Achievement.
PUB DATE 88
NOTE 36p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (61st, Lake of the Ozarks, MO, April 10-13, 1988). For related documents, see SE 049 091-092. Contains some small and broken type.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Achievement; Cognitive Processes; *Critical Thinking; *Formal Operations; Intermediate Grades; *Logical Thinking; *Predictor Variables; Secondary Education; *Sex Differences

ABSTRACT

The purposes of this descriptive-predictive study were to investigate the logical and critical thinking abilities of a sample of sixth through twelfth grade students (N=173) and to determine whether logical thinking processes are predictors of critical thinking abilities and academic achievement. The instruments administered in this study were (1) Group Assessment of Logical Thinking (GALT); (2) Watson-Glaser Critical Thinking Appraisal; (3) Ross Test of Higher Cognitive Abilities; (4) SRA; and (5) MAT6. Although significant gender differences were not found for the total scores on the GALT, Ross, and Watson-Glaser, a significant gender difference in favor of the males was found for probabilistic reasoning on the GALT. The five formal reasoning modes on the GALT were predictors of critical thinking as measured by the Ross and the Watson-Glaser. Also, the formal operational modes on the GALT were significant predictors of academic achievement. The results of this study indicated that a significant percentage of students in grades six through twelve were neither logical nor critical thinkers. (Author/TW)

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LOGICAL AND CRITICAL THINKING ABILITIES OF SIXTH THROUGH TWELFTH GRADE STUDENTS AND FORMAL REASONING MODES AS PREDICTORS OF CRITICAL THINKING ABILITIES AND ACADEMIC ACHIEVEMENT

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Abstract

The purposes of this descriptive-predictive study were to investigate the logical and critical thinking abilities of a convenience sample of sixth through twelfth grade students (N = 173) and to determine whether logical thinking processes are predictors of critical thinking abilities and academic achievement. The instruments administered in this study are as follows: (a) the Group Assessment of Logical Thinking (GALT) (Roadrangka, Yeany, & Padilla, 1982), (b) the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980), (c) the Ross Test of Higher Cognitive Abilities (Ross & Ross, 1976), (d) the SRA, and (e) the MAT6. The authors of the instruments have established the necessary validities and reliabilities on the instruments. The GALT was administered to the total sample during September 1986 and the other instruments were administered during May 1987. The percentages per reasoning level for the total sample are 11% formal, 16% transitional, and 73% concrete. On all subtests and the total Ross, this sample fell below the mean scores of the norm groups. This sample surpassed or equaled the mean scores of the norm group except for the ninth grade group on the Watson-Glaser. Although significant gender differences were not found for the total scores on the GALT, Ross, and Watson-Glaser, a significant gender difference in favor of the males was found for probabilistic reasoning on the GALt. The five formal reasoning modes on the GALT were predictors of critical thinking as measured by the Ross and the Watson-Glaser. Also, the formal operational modes on the GALT were significant predictors of academic achievement. The results of this study indicate that a significant percentage of students in grades six through twelve are neither logical or critical thinkers, and yet the complexity of the twenty-first century demands these abilities.

Logical and Critical Thinking Abilities of Sixth through Twelfth Grade Students and Formal Reasoning Modes as Predictors of Critical Thinking Abilities and Academic Achievement

Piagetian formal operational reasoning (Capie, Newton, & Tobin, 1981; DeCarcer, Gabel, & Staver, 1978; Inhelder & Piaget, 1958; Lawson, 1982a; Lawson, 1985; Linn, 1982) and critical thinking skills (Adler, 1983; Blosser, 1985; Boyer, 1983; National Science Board Commission, 1983) both generic skills (de Bono, 1983) and subject-specific skills (McPeak, 1981), have been identified as essential abilities for success in advanced secondary school courses. In addition, Watson & Glaser (1980) found high correlations between the scores on the Watson-Glaser Critical Thinking Appraisal and measures of academic achievement, measures of general intelligence, and aptitude tests such as the College Entrance Examination Board, Miller Analogies Test, and Scholastic Aptitude Test. Furthermore, formal operational reasoning has been found to be a predictor of achievement in science and mathematics

(Bitner, 1986; Hofstein & Mandler, 1985; Howe & Durr, 1982; Lawson, 1983a).

Formal operational reasoning and critical thinking have been documented as necessary for success in upper level courses, but are secondary students able to use formal operational reasoning and critical thought processes? In a sample of students in grades seven through twelve, Lawson and Renner (1975) found the following percentages of formal operational reasoners per grade: 1% of seventh, 3% of eighth, 5% of ninth, 5% of tenth, 8% of eleventh, and 12% of twelfth. Similar results have been reported by Bitner (1986, 1987); Roadrangka, Yeany, and Padilla (1983); and Karplus, Karplus, and Paulsen (1979).

On both abstract and concrete tasks, formal operational thinkers outperformed transitional operational thinkers (Cantu & Herron, 1978; Hofstein & Mandler, 1985; Lawson & Renner, 1975; Lawson, Lawson, & Lawson, 1984). Also, gender differences in favor of males have been reported (Farrell & Farmer, 1985; Hofstein & Mandler, 1985; Meehan, 1984; Karplus et al., 1979).

The purpose of this study was to investigate

the logical and critical thinking abilities of sixth through twelfth grade students and to determine whether logical thinking processes are predictors of critical thinking abilities and achievement in science, mathematics, language arts, and social studies. Specifically, the following questions were answered.

1. What are the logical thinking abilities of sixth through twelfth grade students as measured by the Group Assessment of Logical Thinking (GALT)?
2. What are the critical thinking abilities of sixth through eighth grade students as measured by the Ross Test of Higher Cognitive Processes?
3. What are the critical thinking abilities of ninth through twelfth grade students as measured by the Watson-Glaser Critical Thinking Appraisal?
4. Are there gender differences in thinking abilities as measured by the GALT, the Ross Test of Higher Cognitive Abilities, and the Watson-Glaser Critical Thinking Appraisal?

5. Are the five formal operational modes of thinking as measured by the GALT predictors of critical thinking processes of sixth through eighth grade students as measured by the Ross Test of Higher Cognitive Processes?
6. Are the five formal operational modes of thinking as measured by the GALT predictors of critical thinking processes of ninth through twelfth grade students as measured by the Watson-Glaser Critical Thinking Appraisal?
7. Are the five formal operational modes of reasoning as measured by the GALT predictors of academic achievement as measured by standardized achievement tests (i.e., MAT6 and SRA) and grades assigned by teachers?

Method

Sample

A convenience sample (N = 173) of all students in sixth through twelfth grades in a consolidated school district in rural Arkansas was used in this

descriptive-predictive study. The project was funded by the Winthrop Rockefeller Foundation.

Instrumentation

The instruments used in this study include the following: (a) the Group Assessment of Logical Thinking (Roadrangka, Yeany, & Padilla, 1982) (b) the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980), (c) the Ross Test of Higher Cognitive Processes (Ross & Ross, 1976), (d) the SRA, and (e) the MAT6. Included in the subsequent paragraphs are descriptions of the content, of the validity, and of the reliability of each of the three instruments.

The abbreviated GALT (Roadrangka et al., 1982) a twelve-item paper and pencil test of logical thinking consists of six modes of reasoning, one concrete operational (i.e., conservation) and five formal operational (i.e., proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning, and combinatorial logic). Construct and criterion-related validities were established for the GALT (Roadrangka et al., 1983) on a sample of students ranging from sixth grade through college . Also, a reliability coefficient

of .85 was found for the GALT and between the Piagetian Interview Tasks and the GALT. The rationale for selecting the GALT as the instrument to measure logical thinking can be found in Roadrangka et al. (1983).

The Ross Test of Higher Cognitive Abilities (Ross & Ross, 1976), a 105-item test designed to measure higher cognitive abilities such as analysis, synthesis, evaluation, critical thinking, logical thinking, inquiry processes, and problem solving, contains the following subtests: analogies, deductive reasoning, missing premises, abstract relations, sequential synthesis, questioning strategies, analysis of relevant and irrelevant information, and analysis of attributes. The norm group consisted of samples of 527 gifted and 610 non-gifted students in grades fourth through sixth. Internal consistency by the split-half reliability method yielded a coefficient of .92; the coefficient of stability resulted in a .94 coefficient. In addition, construct validity was established.

Both forms A and B of the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980)

contain 80 items and five subtests (i.e., inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments) constructed to measure critical thinking abilities. The validation samples for the Watson-Glaser Critical Thinking Appraisal included students in ninth through college, nursing students, medical students, police officers, and sales representatives. Internal consistency by the split-half procedure for the ninth through twelfth grade students ranged between .76 and .79. In addition, a coefficient of stability .73 was found on a group of college students (N = 96). The coefficient of equivalence for a group of twelfth grade students resulted in a coefficient of .75. Both content and construct validities were established also. In addition, the instrument correlates with standard measures of aptitude, intelligence, and achievement as well as grade point average and course grades assigned by teachers. Form B of the Watson-Glaser was used in the present study.

The abbreviated GALT was administered to the total sample in September 1986. The other

instruments were administered in May 1987. The Ross Test of Higher Cognitive Abilities was administered to students in grades six through eight. The Ross was used for this subgroup of the sample because the sample included students of all abilities, even those in resource programs. The Watson-Glaser was administered to students in grades nine through twelve. In addition, students in sixth, seventh, and tenth grades completed the MAT6. The SRA was administered to students in grades eight and nine. Because of the school's evaluation policy and practices, students in grades eleven and twelve did not take a standardized achievement test. The tests were scored by the school counselor and researcher. The teacher assigned grades in mathematics, science, language arts, and social studies were collected in May 1987.

Results

Statistical programs from SPSSX User's Guides, Edition 2 (SPSS, 1986) and Statistics with Finesse (Bolding, 1985) were used to compute the data. All analyses were tested at the .01 level of significance.

Logical Thinking Abilities of Sixth through Twelfth Grade Students

The test analysis of the abbreviated GALT for the sample (N = 173) yielded a Cronbach's alpha coefficient of .80. In Table 1, the means and standard deviations for the GALT indicate the modes of reasoning from most abstract to least abstract are as follows: (a) correlational reasoning (M = .14, SD = .37), (b) probabilistic reasoning (M = .36, SD = .74), (c) proportional reasoning (M = 42, SD = .65), (d) combinatorial logic (M = .62, SD = .70), (e) controlling variables (M = .71, SD = .78), and (f) conservation (M = 1.27, SD = .74). The maximum number of points per reasoning mode is two. The mean of the tenth grade group (M = 4.94, SD = 3.17) surpassed all other groups in the sample.

Reported in Table 2 are the percentages of reasoning levels for the total sample (N = 173), genders, and grade levels. In this sample of sixth through twelfth grade students, 11% were formal operational, 16% transitional operational, and 73% concrete operational.

Critical Thinking Abilities of Sixth through Eighth Grade Students

As reported in Table 3, the means and standard deviations on the subtests of the Ross for sixth through eighth grade students (N = 72) seem to indicate the difficulty level from most to least difficult as follows: (a) sequential synthesis (M = 3.49, SD = 3.19), (b) missing premises (M = 3.84, SD = 1.86), (c) analogies (M = 5.94, SD = 4.89), (d) relevant and irrelevant information (M = 6.81, SD = 2.74), (e) abstract relations (M = 7.25, SD = 4.21), (f) deductive reasoning (M = 7.41, SD = 4.50), (g) questioning strategies (M = 7.54, SD = 2.73), and (h) analysis of attributes (M = 9.16, SD = 17.84). On all subtests except sequential synthesis and the total of the Ross, this sample fell below the mean of the norm group (see Table 3).

Critical Thinking Abilities of Ninth through Twelfth Grade Students

The result of the test analysis on the Watson-Glaser Critical Thinking Appraisal yielded a K-R 20 coefficient of .70. On the Watson-Glaser, the sample of students in ninth through twelfth grade

(N = 101) exceeded or equaled the mean scores of the norm groups except for ninth grade group (see Table 4). Except for the subtest inference, little variation in the mean scores was found among the subtests of the Watson-Glaser (see Table 5).

Gender Differences in Thinking Abilities

The results of one-way analysis of variance did not indicate significant gender differences in logical and critical thinking abilities for the total scores on the GALT, Ross, and Watson-Glaser. However, the males did perform significantly greater (M = .48, $t(94) = 1.75$, $p<.01$) than did the females (M = .23) on probabilistic reasoning on the GALT.

Five Formal Operational Modes of Reasoning Predictors of Critical Thinking Processes

The results of the multiple regression equations for the five formal reasoning modes on the GALT as independent variables and the subtests on the Ross as dependent indicate that logical thinking as measured by the GALT is a predictor of critical thinking as measured by the Ross (see Table 7).

All five formal operational modes of the GALT

are significant predictors of critical thinking processes as measured by the Watson-Glaser (see Table 8). In addition, the formal operational mode proportionality significantly predicted to the subtests, inference, deductions, interpretations, and evaluation of arguments

Five Formal Operational Modes of Reasoning Predictors of Critical Thinking Processes

The five formal reasoning modes on the GALT are significant predictors of academic achievement. All five formal operational reasoning modes of the GALT significantly predicted mathematics achievement, language arts achievement, and the composite score on the SRA for students in grades eight and nine. In addition, combinatorial logic predicts to reference skills, proportionality to science achievement, and controlling variables to social studies achievement (see Table 9).

The results of the stepwise regression analysis for the five logical reasoning modes as independent variables and MAT6 scores as dependent variables indicated the following (see Table 10): (a) All five modes are predictors of mathematics achievement and the composite SRA score.

(b) Combinatorial logic is a significant predictor of reading and language arts achievement as measured by the SRA.

All five formal operational reasoning modes of the GALT are significant predictors of grades in science, mathematics, language arts, and social studies (see Table 11).

Conclusions

The need for formal operational reasoning (Capie et al., 1981; DeCarcer et al., 1978; Inhelder & Piaget, 1958; Lawson, 1982a; Lawson, 1985; Linn, 1982) and critical thinking skills (Adler, 1983; Blosser, 1985; Boyer, 1983; de Bono, 1983; McPeak, 1981; National Science Board Commission, 1983) has been documented. And yet the question remains Are students in sixth through twelfth grade functioning at the formal operational level as measured by the GALT and using critical thinking skills as measured by the Ross and Watson-Glaser?

The percentage of formal operational reasoners (11%) as measured by the GALT for this sample (N = 173) were slightly higher than those reported by Lawson & Renner (1975), Roadrangka et al. (1983),

and Karplus et al. (1979). Of particular interest are the percentages of tenth grade students (27%) and of twelfth grade students (23%) who functioned at the formal operational reasoning level on the GALT. Are these results evidence that students in grades sixth through twelfth grade are functioning at the formal operational level?

The results of the critical thinking tests seem to indicate that the sixth through eighth grade students (N = 72) as measured by the Ross are functioning below the norm group, whereas the students in ninth through twelfth grade (N = 101) except for the ninth graders as measured by the Watson-Glaser are functioning at or above the norm group of ninth through twelfth grade students. On the 105-item Ross, the M = 59.73. On the 80-item Watson-Glaser, the M = 46.76.

Unlike previously reported studies (Farrell & Farmer, 1985; Hofstein & Mandler, 1985; Meehan, 1984; Karplus et al., 1979), overall gender was not a significant variable in logical or critical thinking. Therefore, both genders should be expected to respond to similar approaches to teaching logical and critical thinking.

Results of research in which the GALT was used as the measure of logical thinking indicated that the GALT is a valid and reliable instrument of logical thinking. Logical thinking as a predictor of achievement in science and mathematics has been found (Bitner, 1986; Hofstein & Mandler, 1985; Howe & Durr, 1982; Lawson, 1983a). In this study, the five formal operational modes in the GALT were found to be predictors of critical thinking as measured by the Watson-Glaser and the Ross. In addition, the five formal operational modes in the GALT predicted to mathematics achievement, language arts achievement, and the composite score on the SRA and to mathematics achievement and the composite score on the MAT6. Finally, the five formal operational modes in the GALT were found to be significant predictors of grades assigned by teachers in science, mathematics, language arts, and social studies. Therefore, the development of logical thinking processes should be emphasized in our schools.

The findings of this study support the findings of recent studies which led to the labeling of the eighties as the "Crisis in

Education". The majority of students are not functioning at the formal operational level and are not utilizing critical thinking skills, and yet successful mastery of curriculum at the upper levels demands such processes or skills. The incongruency between the "state of the art" in higher level thinking skills and demands for higher level thinking must be addressed. If indeed survival in the 21st century necessitates the use of higher order thinking skills, it seems imperative that educators overhaul current curriculum to include higher order thinking processes.

References

Adler, M. L. (1983). Paideia problems and possibilities. A consideration of questions raised by the paideia proposal. New York: Collier Books Macmillan.

Bitner, B. L. (1986, March). The GALT: A measure of logical thinking ability of eighth grade students and a predictor of science and mathematics achievement. Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Bitner, B. L. (1987, April). The Galt: A measure of logical thinking ability of 7th through 12th grade students. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Washington, DC.

Blosser, P. E. (1985, Fall). Science education for the year 2000 and beyond. (In R. K. James & V. R. Kurtz, Science and Mathematics Education for the Year 2000 and Beyond. (pp.52-82). Bowling Green, OH: School Science and Mathematics Association.

Boyer, E. L. (1983). High school: A report on secondary education in America. New York:

Harper & Row.

Capie, W., Newton, R., Tobin, K. G. (1981, May). Developmental patterns among formal reasoning skills. Paper presented at the Eleventh Annual symposium of the Jean Piaget Society, Philadelphia, PA.

de Bono, E. (1983). The direct teaching of thinking as a skill. Phi Delta Kappan, 64, 703-707.

DeCarcer, I. A., Gabel, D. L., Staver, J. R. (1978). Implications of Piagetian research for high school science teaching: A review of the literature. Science Education, 62(4), 571-583.

Farrell, M. A., & Farmer, W. A. (1985). Adolescents' performance on a sequence of proportional reasoning tasks. Journal of Research in Science Teaching, 22(6), 503-518.

Hofstein, A., & Mandler, V. (1985). The use of Lawson's test of formal reasoning in the Israeli science education context. Journal of Research in Science Teaching, 22(2), 141-152.

Howe, A. C., & Durr, B. P. (1982). Analysis of an instructional unit for level of cognitive demand. Journal of Research in Science Teaching,

19(3), 217-224.

Inhelder, B., & Piaget, J. (1958). The growth of logical thinking from childhood to adolescence. U.S.A.: Basic Books.

Karplus, R., Karplus, E., Paulsen, A. C. (1979). Proportional reasoning and control of variables in seven countries. (In J. Lochhead & J. Clement (Eds.). Cognitive process in instruction. (pp. 47-103). Philadelphia: The Franklin Institute Press.

Lawson, A. E. (1982a). Formal reasoning, achievement, and intelligence: An issue of importance. Science Education, 66(1), 77-83.

Lawson, A. E. (1983a). Predicting science achievement: The role of developmental level, disembedding ability, mental capacity, prior knowledge, and beliefs. Journal of Research in Science Teaching, 20(2), 117-129.

Lawson, A. E. (1985). A review of research on formal reasoning and science teaching. Journal of Research in Science Teaching, 22(7), 569-617.

Linn, M. C. (1982). Theoretical and practical significance of formal reasoning. Journal of Research in Science Teaching, 19(9), 727-742.

McPeak, J. (1981). Critical thinking and education. St. Martin's Press.

National Science Board Commission on Precollege Education in Mathematics, Science and Technology. (1983). Educating Americans for the 21st century: A plan of action for improving mathematics, science and all technology education for all American elementary and secondary students so that their achievement is the best in the world by 1995. Washington, DC: National Science Foundation.

Roadrankga, V., Yeany, R., & Padilla, M. (1982, December). GALT, Group test of logical thinking. University of Georgia, Athens, GA.

Roadrangka, V., Yeany, R. H., Padilla, M. J. (1983, April). The construction and validation of group assessment of logical thinking (GALT). Paper presented at the annual meeting of the National Association for Research in Science Teaching, Dallas, TX.

Ross, J. D., & Ross, C. M. (1976). Ross test of higher cognitive processes manual. Novato, CA: Academic Therapy Publications.

SPSS* user's guide (2nd ed.) (1986). Chicago, IL:

SPSS Inc.

Watson, G., & Glaser, E. M. (1980). Watson-Glaser critical thinking appraisal. Harcourt Brace Jovanovich.

Table 1

Mean and Standard Deviation on the GALT for 6th through 12th Grade Students Answering Each Item Correctly (N = 172)

	Grade															
Reasoning	6		7		8		9		10		11		12		Total	
Skill	(n = 22)		(n = 27)		(n = 23)		(n = 28)		(n = 30)		(n = 25)		(n = 17)		(N = 172)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Con	1.00	.69	.78	.75	1.35	.78	1.60	.57	1.53	.62	1.31	.74	1.28	.75	1.27	.74
#1	.68	.48	.52	.51	.83	.39	.93	.26	.94	.25	.69	.47	.77	.44	.77	.43
#4	.32	.48	.26	.45	.52	.51	.68	.48	.59	.50	.62	.50	.59	.51	.52	.50
Prop Reas	.09	.29	.07	.27	.17	.49	.50	.69	.71	.82	.62	.70	.67	.69	.42	.65
#8	.05	.21	.00	.00	.04	.21	.39	.74	.38	.49	.19	.40	.17	.38	.14	.35
#9	.05	.21	.07	.27	.13	.34	.40	.50	.38	.49	.42	.50	.44	.51	.28	.45
Cont Var	.23	.53	.22	.58	.65	.78	.79	.74	1.10	.71	.96	.77	.83	.91	.71	.78
#11	.14	.35	.11	.32	.39	.50	.36	.49	.63	.49	.31	.47	.29	.47	.34	.48
#13	.09	.29	.11	.32	.26	.45	.43	.50	.47	.51	.65	.49	.47	.51	.37	.48
Prob Reas	.14	.35	.07	.38	.26	.62	.18	.55	.73	.94	.54	.91	.67	.91	.36	.74
#15	.09	.29	.04	.19	.13	.34	.07	.26	.38	.49	.27	.45	.35	.49	.19	.39
#16	.05	.21	.04	.19	.13	.34	.11	.32	.38	.49	.27	.45	.24	.44	.18	.39
Correl Reas	.05	.21	.07	.27	.17	.49	.11	.32	.23	.43	.23	.43	.11	.32	.14	.37
#17	.05	.21	.07	.27	.13	.34	.11	.32	.25	.44	.19	.40	.06	.24	.14	.34
#18	.00	.00	.00	.00	.04	.21	.00	.00	.03	.18	.04	.20	.00	.00	.02	.13
Comb Reas	.50	.60	.30	.47	.61	.72	.46	.58	.80	.76	.85	.73	.94	.87	.62	.70
#19	.41	.50	.30	.47	.48	.21	.42	.41	.59	.50	.58	.50	.53	.51	.44	.50
#20	.14	.35	.00	.00	.13	.34	.29	.46	.22	.42	.27	.45	.35	.49	.20	.40
GALT Total	2.00	1.48	1.52	1.65	3.26	2.42	3.68	1.95	4.94	3.17	4.50	2.77	4.24	3.09	3.50	2.71

Table 2

Proportion of Students According to the Level of Reasoning as Measured on the GALT and Gender for 6th through 12th Grade Students

Grade	Level of Reasoning					
	Formal[a]		Transitional[b]		Concrete[c]	
	F	%	F	%	F	%
6th (n = 22)	0	0	1	5	21	95
Male (n = 10)	0	0	1	5	9	41
Female (n = 12)	0	0	0	0	12	54
7th (n = 27)	0	0	1	4	26	96
Male (n = 12)	0	0	0	0	12	44
Female (n = 15	0	0	1	4	14	52
8th (n = 23)	1	4	6	26	16	70
Male (n = 14)	1	4	4	17	9	39
Female (n = 9)	0	0	2	9	7	30
9th (n = 28)	1	4	5	18	22	79
Male (n = 16)	0	0	2	7	14	50
Female (n = 12)	1	3	3	11	8	29
10th (n = 30)	8	27	7	23	15	50
Male (n = 17)	5	17	3	10	9	30
Female (n = 13)	3	10	4	13	6	20
11th (n = 25)	4	16	7	28	14	56
Male (n = 13)	3	12	4	16	6	24
Female (n = 12)	1	4	3	12	8	32
12th (n = 17)	4	23	1	6	12	71
Male (n = 10)	3	18	0	0	7	41
Female (n = 7)	1	6	1	6	5	29
Total (N = 172)	18	11	28	16	126	73

[a]Formal = Level 3, score 8-12; *M* = 9.0, *SD* = 2.15.
[b]Transitional = Level 2, score 5-7; *M* = 5.82, *SD* = .17.
[c]Concrete = Level 1, score 0-4; *M* = 2.18, *SD* = 1.23.

Table 3

Comparison of Means and Standard Deviations on the Subtests and Total of Ross Test of Higher Cognitive Processes for 6th through 8th Grade Students (N = 72) and the Non-Gifted Sixth Grade Norm Group (N = 271)

Cognitive Processes	Sample (N = 72)		Norm Group (N = 271)	
	M	SD	M	SD
Analogies	5.94	4.89	8.14	2.82
Deductive Reasoning	7.41	4.50	12.81	2.66
Missing Premises	3.84	1.86	4.07	2.05
Abstract Relations	7.25	4.21	11.54	3.11
Sequential Synthesis	3.49	3.19	3.34	2.80
Questioning Strategies	7.54	2.73	6.95	2.31
Relevant/ Irrelevant Information	6.81	2.74	6.88	2.60
Analysis of Attributes	9.16	2.57	10.30	2.14
Total	59.73	17.84	63.96	14.48

Note 1. The Ross consists of 105-items.

Table 4

Comparison of Means and Standard Deviations on the Watson-Glaser Critical Thinking Appraisal for 9th through 12th Grade Students (N = 101) and the 9th through 12th Grade Norm Group (N = 7,106)

	Sample (N = 101)		Norm Group (N = 7,106)	
	M	SD	M	SD
9th	39.32	10.08	42.60	8.70
10th	51.32	9.75	45.80	9.70
11th	46.60	9.73	46.60	9.73
12th	49.35	7.93	48.50	9.90

Table 5

Mean and Standard Deviation on the Subtests of Watson-Glaser Critical Thinking Appraisal 9th through 12th Grade Students (N = 101)

	Grade										
	9		10		11		12		Total		Total
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Cognitive	(n = 16)	(n = 12)	(n = 17)	(n = 13)	(n = 13)	(n = 13)	(n = 10)	(n = 7)	(n = 56)	(n = 45)	(N = 101)
Processes	M/SD	M/SD	M/SD	M/SD	M/SD	M/SD	M/SD	M/SD	M/SD	M/SD	M/SD
Inferences	6.58	5.00	8.18	7.27	6.90	6.30	4.80	5.86	6.05	5.86	6.44
	3.18	*2.14*	*2.86*	*2.76*	*3.03*	*2.75*	*3.49*	*2.97*	*3.39*	*2.79*	*2.99*
Recognition of Assumptions	9.18	8.75	11.40	10.46	10.80	10.70	5.00	4.00	7.91	7.71	8.78
	2.64	*4.03*	*3.10*	*3.56*	*3.33*	*2.87*	*2.31*	*3.56*	*4.11*	*4.29*	*4.23*
Deductions	8.56	7.63	10.10	9.55	9.60	8.70	4.70	6.71	6.61	6.21	8.32
	1.70	*3.70*	*2.96*	*2.34*	*2.84*	*1.57*	*3.37*	*2.75*	*4.12*	*4.08*	*3.07*
Interpretations	8.62	8.13	11.00	10.91	11.30	8.80	3.70	3.14	7.03	5.68	8.51
	2.57	*3.83*	*3.16*	*3.30*	*2.00*	*2.70*	*3.13*	*4.05*	*5.96*	*4.67*	*4.12*
Evaluation of Arguments	8.64	8.50	11.50	12.00	10.20	9.90	3.90	1.29	6.01	6.28	8.64
	1.96	*2.07*	*2.99*	*1.67*	*3.85*	*1.66*	*2.64*	*1.25*	*4.47*	*4.26*	*4.11*
Total	41.18	36.75	52.20	50.18	48.80	44.40	50.20	48.14	28.56	23.86	46.76
	7.24	*13.18*	*11.28*	*9.03*	*11.98*	*6.75*	*10.05*	*3.63*	*24.64*	*23.20*	*10.36*

Note 1. Standard deviation is italicized.

Table 6

Mean and Standard Deviation on the Subtests of Ross Test of Higher Cognitive Processes for 6th through 8th Grade Students (N = 72)

	Grade															
	6				7				8				Total			
	Male		Female		Male		Female		Male		Female		Male		Female	
Cognitive	(n = 10)		(n = 12)		(n = 12)		(n = 15)		(n = 14)		(n = 9)		(n = 36)		(n = 36)	
Processes	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Analogies	7.60	2.50	7.50	2.34	9.56	3.05	8.36	4.18	7.91	4.70	10.22	2.59	5.41	5.13	5.67	4.78
Deductive Reasoning	11.00	2.31	10.83	2.13	11.56	3.81	12.57	3.92	8.09	6.20	13.56	3.32	6.62	4.15	8.21	4.79
Missing Premises	2.60	.97	3.67	1.72	3.89	2.03	3.79	1.71	4.09	2.74	5.33	1.19	3.47	2.06	4.17	1.69
Abstract Relations	8.80	3.71	9.08	4.21	8.89	4.68	11.14	4.09	7.09	5.79	12.44	1.24	6.74	3.85	7.71	4.60
Sequential Synthesis	2.00	2.75	1.83	2.37	4.44	2.88	4.07	2.17	5.09	4.55	3.78	3.38	3.87	3.69	3.23	2.71
Questioning Strategies	6.10	2.69	6.25	2.96	8.00	2.18	7.79	2.58	8.09	2.47	9.66	1.66	7.40	2.55	7.74	2.79
Relevant/ Irrelevant Information	5.10	2.56	5.67	1.72	7.11	2.85	7.07	3.03	7.27	3.13	8.78	2.22	6.50	2.95	7.03	2.66
Analysis of Attributes	7.80	1.99	8.92	1.88	9.44	2.19	9.43	3.46	9.18	2.27	9.89	3.33	8.80	2.20	9.37	2.91
Total	50.30	9.45	53.59	12.72	62.89	17.84	63.92	20.63	56.82	23.86	73.67	12.03	56.47	18.38	62.82	17.55

Table 7

Stepwise Regression Analysis: Five Logical Reasoning Modes in the GALT Independent variables and Critical Thinking Categories in the Ross Test of Higher Cognitive Processes

	Analogies			Deductive Reasoning			Missing Premises			Abstract Relations			Sequential Synthesis		
Step	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F
1	PROPT	.04	5.38*	PROPT	.05	7.63**	CONT	.19	14.89***	COMBT	.03	.90	COMBT	.07	.85
2	COMBT	.07	5.71**	CORRT	.08	2.34*	CORRT	.24	3.88**	CORRT	.03	.90	CORRT	.07	.85
3	CORRT	.08	2.49	COMBT	.08	2.34*	PROPT	.24	3.88**	PROPT	.03	.90	PROPT	.07	.85
4	CONT	.08	2.49	CONT	.08	2.34*	COMBT	.24	3.88**	CONT	.03	.90	CONT	.07	.85
5	PROBT	.08	2.49	PROBT	.08	2.34*	PROBT	.24	3.88**	PROPT	.03	.90	PROBT	.07	.85

*** p<.001
**p<.01
*p<.05

Table 7 (cont.)

Stepwise Regression Analysis: Five Logical Reasoning Modes in the GALI Independent Variables and Critical Thinking Categories in the Ross Test of Higher Cognitive Processes

	Questioning Strategies			Relevant and Irrelevant Information			Analysis of Attributes			Total Ross		
Order	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F
1	COMBT	.08	5.47*	CONT	.17	12.65***	COMBT	.09	1.21	CONT	.16	11.41***
2	CORRT	.10	1.36	CORRT	.23	3.55**	CORRT	.09	1.21	CORRT	.22	3.34**
3	PROPT	.10	1.36	PROPT	.23	3.55**	PROPT	.09	1.21	PROPT	.22	3.34**
4	CONT	.10	1.36	COMBT	.23	3.55**	CONT	.09	1.21	COMBT	.22	3.44**
5	PROBT	.10	1.36	PROBT	.23	3.55**	PROBT	.09	1.21	PROBT	.22	3.44**

*** $p<.001$
** $p<.01$
* $p<.05$

Table 8

Stepwise Regression Analysis: Five Logical Reasoning Modes in the GALT Independent Variables and Critical Thinking Categories in the Watson-Glaser Dependent Variables

	Inference			Recognition of Assumptions			Deductions			Interpretations			Evaluation of Arguments			Total Watson-Glaser		
Step	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F
1	PROPT	.08	9.52**	CORRT	.05	5.86*	PROPT	.06	7.03**	PROPT	.07	8.67**	PROPT	.06	9.40**	PROPT	.26	49.82***
2	CORRT	.11	2.56*	PROPT	.09	1.91	CORRT	.11	2.38*	CORRT	.10	2.17	CORRT	.09	2.77*	CONT	.30	31.00***
3	COMBT	.11	2.56*	COMBT	.09	1.91	COMBT	.11	2.38*	COMBT	.10	2.17	COMBT	.09	2.77*	CORRT	.31	12.85***
4	Cont	.11	2.56*	CONT	.09	1.91	CONT	.11	2.38*	CONT	.10	2.17	COMBT	.09	2.77*	COMBT	.31	12.85***
5	PROBT	.11	2.56*	PROBT	.09	1.91	PROBT	.11	2.38*	PROBT	.10	2.17	PROBT	.13	2.77*	PROBT	.31	12.85***

*** p<.001
** p<.01
* <.05

Table 9

Stepwise Regression Analysis: Five Logical Reasoning Modes in the Half Independent Variables and SRA Achievement Scores* Dependent Variables

	Science			Mathematics			Social Studies			Language Arts		
Order	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F
1	PROPT	.17	7.59**	CONT	.19	17.59***	CONT	.16	7.45**	COMBT	.15	13.33***
2	CORRT	.20	1.66	COMBT	.24	11.69***	CORRT	.23	2.07	CONT	.20	9.33***
3	COMBT	.20	1.66	CORRT	.24	4.51***	PROPT	.23	2.07	CORRT	.21	3.86**
4	CONT	.20	1.66	PROPT	.24	4.51***	COMBT	.23	2.07	PROPT	.21	3.86**
5	PROBT	.20	1.66	PROBT	.24	4.51***	PROBT	.23	2.07	PROBT	.21	3.86**

*For students in grades eight and nine.

*** $p<.001$
** $p<.01$
* $p<.05$

Table 10

Stepwise Regression Analysis: Five Logical Reasoning Modes in the GALT Independent Variables and MAT6 Achievement Scores* Dependent Variables

	Reading			Mathematics			Language Arts			Composite		
Order	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F
1	COMBT	.30	15.61***	COMBT	.25	12.34***	COMBT	.18	8.06**	COMBT	.28	14.29***
2	CORRT	.34	3.35*	CORRT	.41	4.57***	CORRT	.33	3.21*	CORRT	.37	3.82**
3	CONT	.34	3.35*	CONT	.41	4.57***	CONT	.33	3.21*	CONT	.37	3.82**
4	PROPT	.34	3.35*	PROPT	.41	4.57***	PROPT	.33	3.21*	PROPT	.37	3.82**
5	PROBT	.34	3.35*	PROBT	.41	4.57***	PROBT	.33	3.21*	PROBT	.37	3.82**

*For students in grades six, seven, and ten.

*** $p < .001$
** $p < .01$
* $p < .05$

Table 11

Stepwise Regression Analysis: Five Logical Reasoning Modes in the GALT Independent Variables and Grades in Science, Mathematics, Social Studies, and Language Arts Dependent Variables

	Science			Mathematics			Social Studies			Language Arts		
Order	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F	Mode	R^2	F
1	CONT	.12	18.27***	CONT	.09	12.89***	PROPT	.08	10.68***	CONT	.08	12.66***
2	COMBT	.17	12.99***	COMBT	.12	8.88***	CORRT	.11	3.20**	COMBT	.10	8.74***
3	CORRT	.18	5.62***	CORRT	.14	4.06**	COMBT	.11	3.20**	CORRT	.10	3.45**
4	PROPT	.18	5.62***	PROPT	.14	4.06**	CONT	.11	3.20**	PROPT	.10	3.45**
5	PROBT	.18	5.62***	PROBT	.14	4.06**	PROBT	.11	3.20**	PROBT	.10	3.45**

*** $p<.001$
** $p<.01$
* $p<.05$